Optik 127 (2016) 5899–5913

Contents lists available at ScienceDirect

Optik

journal homepage: www.elsevier.de/ijleo

Skin-pigmentation-disorder detection algorithm based on projective coordinates

Yang Liu [a,*], Suk-Hwan Lee [b], Seong-Geun Kwon [c], Ki-Ryong Kwon [a]

[a] Department of IT Convergence and Application Engineering, Pukyong National University, Republic of Korea
[b] Department of Information Security, Tongmyong University, Republic of Korea
[c] Department of Electronics Engineering, KyuingIl University, Republic of Korea

A R T I C L E   I N F O

Article history:
Received 24 December 2015
Accepted 6 April 2016

Keywords:
Skin disorder area detection
Hemoglobin
Melanin
Projective HM coordinates
GMM-EM clustering

A B S T R A C T

Our skin is the first line of defense from external environment. It covers whole body and protects the tissues and organs from various external assaults. Skin also keeps a stable internal environment for body's metabolism, like regulating temperature and saving necessary water. Furthermore the nerve of skin gives us tactile sensation, which makes us to better adapt to our living environment. When skin diseases occur, the partial functionality of skin cannot be accomplished. One of fatal diseases is skin cancer. With skin cancer progression, the color of skin will change on different stage. Paper proposes an algorithm to detect and quantize this kind of visual change. The program tries to assist people to diagnosis skin cancer, even self-exam. The proposed algorithm mainly contains three parts. Initially paper segments the skin area from images. Then two main components of skin color are retrieved by ICA. Finally paper estimates if there is pigmentation disorder through comparing the ratio of two main components, and a novel comparing model, projective coordinates is used in this process.

1. Introduction

1.1. About our skin and skin cancer

Human is able to adapt various living environments, skin plays a key role. It is the largest organ of body, makes up 5–15% of the total body weight; by area, the total area can reach 1.5–2 m [1]. Skin consists of three layers: the epidermis, dermis and subcutaneous tissue, within layers there are blood vessel, lymphatic vessel, nerve and appendages. Skin covers the whole body, forms an effective barrier between the 'inside' and the 'outside' [2]. For inside, skin keeps water, heat, electrolytes and other substance for body's metabolism. Besides, skin can synthesize vitamin D which is contained in very few foods. For outside, skin protects various tissues and organs from physical, mechanical chemical and pathogenic microorganism assaults. And skin can sense pressure, temperature, vibration and skin stretch through millions of nerve. That is one of the five traditional senses—the tactile sensation, gives us hand dexterity, perception of limb position and so on [3]. So skin is an indispensable part of our body, losing it is catastrophic.

As other body tissue, when skin cells grow old or get damaged, they will die. And skin generates new cells to take the old one's place through cells grow and divide. But sometimes this process may get wrong. The old or damaged cells do not

* Corresponding author.
E-mail address: yangliu.0816@hotmail.com (Y. Liu).

http://dx.doi.org/10.1016/j.ijleo.2016.04.013
0030-4026/

die, or new cells generate when body does not need them. Then tumor is generated with these abnormal cells growth. The malignant of them is cancer. For skin, there are three most common type cancers: melanoma, basal cell cancer and squamous cell cancer. These three cancers have difference incidence rates for different ethnic groups. Melanoma begins in melanocytes. It usually occurs in people with light and fair skin. Melanoma is listed in the common cancer types in the United States [4], but it is rare in people with dark skin. Basel cell skin cancer begins in the basal cell layer of skin. In people with light and fair skin, basal cell skin cancer is the most common type of skin cancer. But squamous cell skin cancer which begins in squamous cells is the most common type of skin cancer in people with dark skin. Like other common cancers, skin cancer can spread throughout the body, and invade the normal tissue nearby. Melanoma is more likely to spread to other parts of the body than other two. The next is squamous cell skin cancer, and basal cell skin cancer rarely does. Skin cancer is rarely a threat to life at first, for instance, melanoma has a very high survival rate [5]. At the beginning of growth, Skin cancer does not have the ability to invade or spread other cells in this phase. And usually does not grow back after it's removed. But if it becomes malignant growths, the cancer will be a threat to life. So early detection and timely treatment are the key to cure skin cancers.

1.2. Detection of skin disorder area

There are many risk factors for skin cancer. A major factor is an overdose of UV radiation of giving to the skin. For example, long-term sunlight exposure or get too much sunlamps and tanning booths. The next is family history, people who has skin cancer family history has a higher probability of getting the skin cancer. And some medicines or medical conditions may cause your skin more sensitive to the sun then increase the risk of skin cancer. As other cancers, a biopsy is needed to confirm skin cancers. But before that there are some symptoms can be recognized. For instance, when melanoma occurs, the first sign comes from visual features of shape, color or size. Different from mole, melanoma is rarely symmetry, and the border is irregular. The color of skin cancer region is uneven, part of skin changes red or darker color. And the area of the region usually increases as time goes on.

For detecting this kind of change accurately, People use various optical devices in dermatology, like the reflectance measurement [6–8] and the skin-colorimeter [9,10]. Because the results are sensitive to the amount of light radiation, all this kind of devices spend much money on keeping a stable illumination environment and the precision optical components. Then the cost hinders the application development. Recently vision-based methods have been proposed for detecting skin disorder area instead of optical measurements.

Clawson et al. [11] evaluated the skin pigment asymmetry by visually displaying and quantifying color asymmetry. This method aimed to improve preoperative diagnostic accuracy by quantifying features that indicate skin cancer, such as malignant melanoma. Madasu and Lovell [12] extended the fuzzy co-clustering algorithm for images (FCCI) by including texture features to detect blotches in skin lesions and by using a normalized entropy function to detect the texture features. Furthermore, they optimized the objective function by using the bacterial foraging algorithm that gives image-specific values to clustering parameters.

Vision-based methods can detect or categorize the pigmented skin disorders more effectively than optical measurements. They developed better software to offset the insufficient in hardware. But the dependence on the stable illumination and hardware requirement is not reduced enough [13–16].

1.3. Two components of skin

We know that the most abundant information of image comes from the boundary, the next is color. For skin disorder area, the boundary is not easy to get, and some of skin disorder area does not have the exact boundary. Skin color is not easy to measure either, not only because of the influence from different illumination environments, but also the difference of skin complexion from different populations [17–19]. All of these factors make it hard to make a simple threshold for distinguishing skin disorder area. From Krishnawwamy [20] research, we can find reason for our different skin complexions. Skin is a multilayerd and inhomogeneous organ. Light is absorbed and propagated in skin tissues by several natural chromophores (Fig. 1). There are two major components of skin complexions, melanin and hemoglobin. Melanin is produced by cells melanocytes. Skin complexion types contain the fair, medium, olive, tan, brown and black, this kind of difference just derives from how many melanosomes per unit volume are in the epdiermis. In the blood cells we find another natural chromophore, hemogolobin, which gives blood its reddish color. And our skin's red just from the small blood vessels under the skin surface.

Skin complexion may have a little change by some reasons, like age-growth, sun tanning, even just a little pressure from our fingers, but our skin complexion is basically stable in a range. Which means the two major components of skin complexion, melanin and hemoglobin have a stable proportional relationship in normal skin. When the skin cancer occur, one of the major change of skin is complexion (Fig. 2). It means proportional relationship is broken. If we can detect the change of the ratio of hemoglobin and melanin, then the skin disorder area can be detected. In this area, Tsumura et al. [21] utilized ICA algorithm to retrieve the hemoglobin and melanin components from a skin image. Then paper tries to detect and measure the size and shape of skin pigmentation by analyzing the hemoglobin and melanin components in the skin.

This paper proposes an algorithm for detecting and quantifying skin pigmentation. The algorithm consists of three parts: initially skin is segmented by the skin color model based on the Gaussian Mixture Models Expectation Maximization (GMM-EM) algorithm. Next paper retrieves the hemoglobin and melanin components from skin image by ICA. Finally paper